A LABORATORY MANUAL

CONTAINING

DIRECTIONS FOR A COURSE OF EXPERIMENTS IN GENERAL CHEMISTRY

Systematically Arranged

TO ACCOMPANY

THE AUTHOR'S "ELEMENTS OF CHEMISTRY"

BY

IRA REMSEN
Professor of Chemistry in the Johns Hopkins University

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NOTE FOR TEACHERS.

On comparing the experiments described in this Manual with those described in my Elements of Chemistry it will be found that some of the more difficult ones have been omitted here. As many as possible of those omitted should be performed by the teacher in the presence of the class; and the points of importance should be drawn out by questions put to the members of the class. Afterwards the pupils should write a full account of what they have seen, and draw such conclusions as the experiments may lead to.

THE AUTHOR.

APPARATUS AND CHEMICALS.

For the benefit of those who have no laboratory at command, and who may wish to make arrangements for performing the experiments described in this book, the following lists have been drawn up. In them is included everything necessary to perform the experiments on a small scale. Should it be desired to fit up a room with conveniences for students, the amount of apparatus necessary will depend upon the number of students, but for each individual the expense will be small, as some of the pieces of apparatus, such as the magnet, weights, scales, etc., need not be multiplied. In place of some of the pieces of apparatus described in the book, ordinary kitchen utensils will answer. Thus, for example, instead of the trough for collecting gases, a tin pan or a deep earthenware dish may be used; instead of the water-bath, a stew-pan, fitted with two or three different-sized tin or sheet-iron rings; in place of glass cylinders for working with gases, wide-mouthed cheap bottles; and in place of Wolff's bottles, wide-mouthed bottles fitted with a cork having two holes. In case of need nearly everything necessary can be procured at an ordinary drug store, though nowadays there is no difficulty in getting the simpler forms of chemical apparatus at little cost.

The publishers do not deal in chemicals and apparatus, nor, they may as well say, receive commissions on them. Any orders should be sent direct to the dealers.

Messrs. Eimer & Amend, Nos. 205 to 211 Third Avenue, New York, whom the publishers take the responsibility of recommending as thoroughly reliable, will furnish each of the following articles at the price given.

If several pieces of the apparatus in List No. 1 are taken, a discount of 10 per cent will be made; on a complete set

20 per cent discount will be allowed; on three or more sets, 25 per cent.

A discount of 10 per cent will be given on a complete set of the chemicals, and of 15 per cent on three or more sets.

For a class of 12 three or four times the amount of apparatus included in List No. 1 could be made to answer, particularly if the pupils are not all required to do the same thing at the same time. As there is, however, always more or less breakage of glass- and porcelain-ware, it is well to have extra pieces of all such apparatus on hand.

As regards chemicals, List No. 2 gives quantities required for a class of 12 as nearly as can be estimated. It is better to have somewhat larger quantities, as some of the experiments may have to be repeated a number of times.

For most items less than the whole set, there will have to be a small additional charge for packing. It should be borne in mind, however, that usually the charge for packing one article must be as large as for several. Some articles can, of course, be mailed without any charge for packing.

List No. 1.

A list of apparatus and chemicals necessary for performing all the experiments described in this book.

APPARATUS.

1 Nest Beakers, 1-3	$0 40
1 Jeweller's Blowpipe, 8 in	15
7 Wide-mouth Flint Bottles, two each, 2, 4, 8 oz., and one 32 oz.	50
1 Bunsen's Burner with regulator, or 6 oz. glass alcohol lamp, same price	50
1 5-in. U-tube	25
2 doz. Assorted Corks	20
1 Set Cork Borers, 1-6	1 00
1 Nest Hessian Crucibles, "threes"	6
1 1¼-in. Porcelain Crucible	18
1 25 CC Grad. Cylinder	50
1 Deflagrating Spoon	25
1 each Evaporating Dish, 2½ and 3½ in	40
1 Lead Dish, 2 in	25
1 Round File, 5 in	25
1 Triangular File, 5 in	25
1 Pack White Filters, 4 in	12
4 Flasks: one 4 oz., two 8 oz., one 16 oz	80
1 Steel Forceps	20
2 Funnels, 2½ in	24
2 Funnel Tubes, one 10 in., one 15 in	$0 35
1 Gas Bottle, 8 oz., with 2-hole R Stopper	40
¼ lb. Assorted Glass Tubing, 4-7	15
2 Sheets each Red and Blue Litmus-paper	20
1 Horseshoe Magnet, 3 in	20
1 Porcelain Mortar and Pestle, 3½ in	45
1 Piece Platinum Foil, 1x1½ in	60
6 in. Medium Platinum Wire	20
1 Plain Retort, 8 oz	30
1 Stoppered Retort, 16 oz	55
3 ft. Rubber Tubing for gas, ¼ in. (Only needed if Bunsen's Burner is used.)	39
2 ft. Rubber Tubing (for connections)	20
1 3½ in. Sand Bath	15
1 Hand Scale, with weights	85
1 Test Tube Stand	30
12 Test Tubes, 5 in	30
1 Test Tube Brush	5
1 Test Tube Clamp	20
1 Iron Tripod	30
2 2-in. Watch-glasses	10

1 5-in. Water-bath	$1 00
2 Wire Clamp Supports	2 00
	$15 74

CHEMICALS.

4 oz. Acid Acetic, pure (bottle 5 cents extra)	$0 10
4 oz. Acid Arsenious	10
16 oz. " Hydrochloric (bottle 15 cents extra)	10
8 oz. Acid Nitric (bottle 12 cents extra)	10
2 oz. Acid Oxalic	10
16 oz. " Sulphuric (bottle 12 cents extra)	10
1 oz. Acid Tartaric	10
2 oz. Alcohol, for experiments only (bottle 4 cents extra)	10
8 oz. Alum	10
4 oz. Ammon. Chloride	10
8 oz. " Hydrate, concentrated (bottle 10 cents extra)	10 10
4 oz. Ammon. Nitrate	10
2 oz. Antimony, powdered	10
2 oz. " and Potassium Tartrate	20
2 oz. Barium Chloride	10
4 oz. Calcium Chloride, fused	10
4 oz. " Sulphate	10
4 oz. Carbon Disulphide (bottle 5 cents extra)	10
8 oz. Animal Charcoal, powdered	10
8 oz. Copper Foil	30
4 oz. " Sulphate	10
1 oz. " Oxide	15
4 oz. Fluorspar, powdered	10
1 oz. Indigo	10
1 oz. Iodine (bottle 2 cents extra)	25
4 oz. Iron Filings, fine	10
8 oz. Iron Sulphide	$0 10
4 oz. " Sulphate	10
4 oz. Lead Sheet	10
4 oz. " Acetate	10
2 oz. " Nitrate	10
1 oz. " Peroxide	10
2 oz. " Sesquioxide	10
1 oz. Litmus	10
½ dram Magnesium Ribbon	10
1 lb. Manganese Dioxide, powdered	10
1 oz. Mercury Red Oxide	10
1 oz. Nutgalls, powdered	10
2 oz. Paraffine	10
1 oz. Phosphorus (bot. 10c. extra)	15
1 dram Potassium	30
2 oz. " Bromide	10
4 oz. " Carbon. (bottle 5 cents extra)	10
4 oz. Potassium Chlorate	10
4 oz. " Dichromate	10
2 oz. " Ferrocyanide	10
4 oz. " Hydrate Sticks (bottle 5 cents extra)	20
1 oz. Potassium Iodide (bottle 5 cents extra)	25
4 oz. Potassium Nitrate	10
2 oz. " Permanganate	10
1 dram Sodium (bot. 3c. extra)	10
2 oz. " Acetate	10
2 oz. " Bicarbonate	10
4 oz. " Biborate (Borax)	10
4 oz. " Hydrate (bottle 5 cents extra)	20
4 oz. Sodium Nitrate	10
4 oz. " Sulphate	10
8 oz. Sulphur, roll	10
4 oz. Tin, granulated	10
16 oz. Zinc, granulated	30
2 oz. " Sulphate	10
	$7 50

List No. 2.

4 oz. Acetic Acid (pure) (bottle 5 cents extra)	$0 10
4 oz. Acid Arsenious	10
6 lbs. Acid Hydrochloric (bottle 25 cents extra)	30
4 lbs. Acid Nitric (bottle 20 cents extra)	48
8 oz. Acid Oxalic	10
9 lbs. Acid Sulphuric (bottle 25 cents extra)	45
2 oz. Acid Tartaric	10
4 oz. Alcohol (bottle 5 cents extra)	15
2 lbs. Alum	15
1 lb. Ammonium Chloride	20
1 lb. Ammon. Hydrate (Conc.) (bottle 15 cents extra)	20
1 lb. Ammon. Nitrate (bottle 10 cents extra)	$0 30
4 oz. Antimony (powd.)	15
2 oz. Antimony and Potassium Tartrate	20
2 oz. Barium Chloride	10
8 oz. Calcium Chloride	12
1 lb. Calcium Sulphate	15
1 lb. Carbon Disulphide (bottle 10 cents extra)	20
2 lbs. Animal Charcoal	20
2 lbs. Copper Foil	1 20
½ lb Copper Sulphate	10
2 oz. Copper Oxide	20
8 oz. Fluorspar (powd.)	10
1 oz. Indigo	10
1 oz. Iodine (bottle 2 cents extra)	25

8 oz. Iron Filings	$0 10
2 lbs Iron Sulphide	30
8 oz. Iron Sulphate	10
1 lb. Lead Sheet	40
½ lb. Lead Acetate	10
4 oz. Lead Nitrate	10
2 oz. Lead Peroxide	15
4 oz. Lead Sesquioxide	10
2 oz. Litmus	10
2 lbs. Manganese Dioxide (coarsely granulated)	30
4 oz. Mercury Red Oxide	30
1 oz. Nutgalls, powdered	10
4 oz. Phosphorus	45
2 drams Potassium	50
4 oz. Potassium Bromide	15
1 lb. Potassium Carbonate (bottle 10 cents extra)	12
2 lbs. Potassium Chlorate	50
½ lb. Potassium Dichromate	10
4 oz. Potassium Ferrocyanide	$0 10
½ lb. Potassium Hydrate (bottle 8 cents extra)	30
2 oz. Potassium Iodide	40
½ lb. Potassium Nitrate	10
4 oz. Potassium Permanganate	15
1 oz. Sodium (bottle 4 cents extra)	30
8 oz. Sodium Acetate (bottle 8 cents extra)	25
½ lb. Sodium Bicarbonate	10
4 oz. Sodium Biborate	10
2 lbs. Sodium Hydrate (sticks)	1 00
1 lb. Sodium Nitrate	12
4 oz. Sodium Sulphate	10
1 lb. Roll Sulphur	10
½ lb. Granulated Tin	25
8 lbs. Ganulated Zinc	90
4 oz. Zinc Sulphate	10
	$14 04

LIST OF EXPERIMENTS.

SYMBOLS AND ATOMIC WEIGHTS OF THE ELEMENTS.

Element.	Symbol.	Atomic Weight.
ALUMINIUM	Al	27.04
Antimony	Sb	119.6
Arsenic	As	74.9
Barium	Ba	136.9
Beryllium	Be	9.08
Bismuth	Bi	207.3
Boron	B	10.9
Bromine	Br	79.76
Cadmium	Cd	111.7
Cæsium	Cs	132.7
CALCIUM	Ca	39.91
CARBON	C	11.97
Cerium	Ce	141.2
CHLORINE	Cl	35.37
Chromium	Cr	52.45
Cobalt	Co	58.74
Columbium	Cb	93.7
Copper	Cu	63.18
Didymium	Di	142.1
Erbium	E	166
Fluorine	F	19.06
Gallium	Ga	69.9
Germanium	Ge	73.32
Gold	Au	196.7
HYDROGEN	H	1
Indium	In	113.4
Iodine	I	126.54
Iridium	Ir	192.5
IRON	Fe	55.88
Lanthanum	La	138
Lead	Pb	206.4
Lithium	Li	7.01
MAGNESIUM	Mg	23.94
Manganese	Mn	54.8
Mercury	Hg	199.8
Molybdenum	Mo	95.9
Nickel	Ni	58.56
NITROGEN	N	14.01
Osmium	Os	191
OXYGEN	O	15.96
Palladium	Pd	106.2
Phosphorus	P	30.96
Platinum	Pt	194.3
POTASSIUM	K	39.03
Rhodium	Rh	104.1
Rubidium	Rb	85.2
Ruthenium	Ru	103.5
Scandium	Sc	43.97
Selenium	Se	78.87
SILICON	Si	28
Silver	Ag	107.66
SODIUM	Na	23
Strontium	Sr	87.3
Sulphur	S	31.98
Tantalum	Ta	182
Tellurium	Te	125
Thallium	Tl	203.7
Thorium	Th	232
Tin	Sn	117.4
Titanium	Ti	48
Tungsten	W	183.6
Uranium	U	239.8
Vanadium	V	51.1
Ytterbium	Yt	172.6
Yttrium	Y	88.9
Zinc	Zn	65.1
Zirconium	Zr	90.4

LABORATORY MANUAL.

GENERAL LABORATORY DIRECTIONS.

1. Neatness is one of the first conditions of success in chemical work. *Keep your laboratory desk, as well as all your apparatus, clean.*

2. Provide yourself with a working-apron to protect your clothing.

3. Always have a decent towel available.

4. In observing *use your own eyes.*

5. In describing experiments *use your own words.*

6. In thinking over the results *use your own mind.*

7. An experiment should be repeated as many times as may be necessary to secure accurate work.

8. If the results obtained are not those which you have been led to expect, try in every way you can think of to find out what the matter is. See first whether you have worked *exactly* as directed.

9. After an experiment is finished, write in your note-book in the laboratory an account of what you have done. If you are able to draw any conclusions from what you have seen, state what these conclusions are. Write the description accurately and in as good English as possible. Do not use abbreviations. In referring to chemical substances do not use simply the symbol, but the full name with the symbol after it. Thus, potassium chlorate, $KClO_3$; hydrochloric acid,

HCl. Further, in speaking of chemical substances do not use symbols. For example, do not say, "I poured some H_2SO_4 into an H_2O solution of $BaCl_2$," but say in English what you did.

10. After you have written an account of an experiment have it examined by the teacher before you go on to the next one.

11. Always read before and after an experiment or a set of experiments that part of the text-book in which the experiment or experiments are referred to, and keep reviewing constantly.

12. If an experiment not included in your course is performed by you or by your teacher, write an accurate account of it as if you had yourself performed it, but do not make any statement without entirely satisfactory reasons for making it.

13. In working with gases see that all the joints of your apparatus are tight.

14. In case of fire a moist towel thrown over the flame will generally be sufficient to extinguish it.

15. Acid wounds should first be washed out, and a paste of sodium carbonate and water then applied.

16. Burns should be treated with a paste of sodium carbonate and water.

HEAT AND CHEMICAL CHANGE.

EXPERIMENT 1.

In a clean *dry* test-tube put enough white sugar to make a layer ¼ to ½ inch thick. Hold the tube in the flame of a spirit-lamp or laboratory burner as shown in Fig. 1.

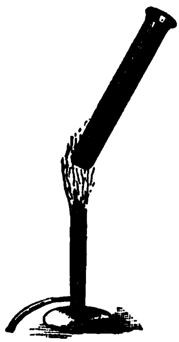

FIG. 1.

What changes take place?

What do you see on the sides of the tube?

What is the color and taste of that which remains behind?

Does it dissolve in water?

Is it sugar?

Is the change which has taken place chemical or physical?

What caused the change?

EXPERIMENT 2.

1. From a piece of glass tubing of about $\frac{3}{8}$ inch internal diameter cut off a piece about 4 inches long by making a mark across it with a triangular file, and then seizing it with both hands, one on each side of the mark, pulling and at the same time pressing slightly as if to break it. Clean and dry it, and hold one end in the flame of a laboratory burner until it melts together. During the melting twirl the tube constantly between the finger and thumb so that the heat may act uniformly upon it. After it has cooled down put into it enough red oxide of mercury (mercuric oxide) to form a layer $\frac{1}{4}$ to $\frac{1}{2}$ inch thick.

2. Heat the tube as in Experiment 1.

What change in color takes place?

What is deposited on the sides of the tube?

3. During the heating insert into the tube a splinter of wood with a spark on the end.

What follows?

4. Take it out and put it back a few times.

Is there any difference between the burning in the tube and out of it?

What difference?

How do you know that the red substance which you put into the tube has been changed?

Is the change chemical or physical?

What caused the change?

Experiment 3.

1. Examine a piece of calc-spar or marble. Notice whether it is hard or soft. Heat a small piece in a glass tube such as used in Experiment 2.

Does it change in any way?

Does it dissolve in water?

2. Knowing now the general properties of the calc-spar or marble you will be able to determine whether it is changed or not. Treat a small piece with dilute hydrochloric acid.

Fig. 2.

What takes place?

3. After the action has continued for about half a minute insert a lighted match in the upper part of the tube.

Does the match continue to burn?

Does the substance in the tube burn?

Is the invisible substance in the upper part of the tube ordinary air?

How do you know?

Does the solid substance disappear?

4. In order to tell whether it has been changed chemically the hydrochloric acid must be gotten rid of. This can be done by boiling it, when it passes off in the form of vapor, just as water does, and then whatever is in solution will remain behind. For this purpose put the solution in a small, clean porcelain

evaporating-dish, and put this on a vessel containing boiling water, or a water-bath. The operation should be carried on in a place where there is a good draught, so that the vapors will not collect in the working-room. They are not poisonous, but they are annoying. The arrangement for evaporating is illustrated in Fig. 2.

5. After the liquid has evaporated and the substance in the evaporating-dish is dry, examine it and carefully compare its properties with those of the substance which was put into the test-tube.

Is it the same substance?

Is it hard or soft?

Does it change when heated in a tube?

Is there an appearance of bubbling when hydrochloric acid is poured on it?

Does it dissolve in water?

Does it change when allowed to lie in contact with the air?

6. In order to learn whether a substance is soluble in water proceed as follows: Put a piece about the size of a pea in a test-tube with distilled water. Thoroughly shake, and then, as heating usually aids solution, boil. Now pour off a few drops of the liquid on a piece of platinum-foil or a watch-glass, and by gently heating cause the water to pass off as steam. If there is anything solid in solution there will be something solid left on the platinum-foil or watch-glass. If not, there will be nothing left.

CONTACT AND CHEMICAL CHANGE.

EXPERIMENT 4.

1. Bring together in a test-tube a small piece of copper and some moderately dilute nitric acid. Hold the mouth of the tube away from your face and do not inhale the vapors.

What is the appearance of the vapors given off?

What is the appearance of the liquid in the tube?

Does the copper dissolve?

2. Examine the solution, as in the preceding experiment, and see what has been formed.

What are the properties of the substance found after the liquid has evaporated?

Is it colored?

Is it hard or soft?

Does it change when heated in a tube?

Is it soluble in water?

Does it in any way suggest the copper with which you started?

CONTACT AND CHEMICAL CHANGE.

Experiment 5.

1. Try the action of dilute sulphuric acid on a little zinc in a test-tube. Apply a lighted match to the mouth of the tube.

What takes place?

2. After the zinc has disappeared evaporate the solution as before. Carefully compare the properties of the substance left behind with those of zinc.

What differences do you find between them?

CONTACT AND CHEMICAL CHANGE.

EXPERIMENT 6.

In a small dry flask of about four ounces capacity put a bit of granulated tin or of pure tin-foil. Pour upon it enough concentrated nitric acid to cover it. If no change takes place at first, heat gently.

What evidence have you that change is taking place?

Is there anything in this experiment which suggests Experiment 4?

What is left behind after the action is finished?

Compare the properties of the product with those of tin.

SOLUTION AIDS CHEMICAL ACTION.

EXPERIMENT 7.

1. Mix together in a dry mortar a little dry tartaric acid and about an equal quantity of dry bicarbonate of soda (sodium bicarbonate).

Do you see any evidence of action?

2. Now dissolve a little tartaric acid in water in a test-tube, and a little bicarbonate of soda in water in another test-tube. Pour the two solutions together.

What evidence have you now that action takes place?

3. Pour water upon the dry mixture first made.

Does action take place?

What causes the bubbling?

Will a match burn in the gas?

In which experiment already performed was a similar gas obtained?

SOLUTION AIDS CHEMICAL ACTION.

EXPERIMENT 8.

1. Mix together in a dry mortar a little dry sulphate of iron (green vitriol) and a little dry ferrocyanide of potassium (yellow prussiate of potash).

Does action take place?

2. Make a solution of each of the two substances and pour them together.

What evidence have you that action takes place?

3. Pour water on the dry mixture.

Does action take place?

MECHANICAL MIXTURE.

Experiment 9.

1. Mix two or three grams of powdered roll-sulphur and an equal weight of very fine iron filings in a small dry mortar. Examine a little of the mixture with a microscope or a magnifying-glass.

Can you distinguish the particles of sulphur and those of iron?

2. Pass a small magnet over the mixture.

Are particles of iron drawn out of the mixture?

Has chemical action taken place?

MECHANICAL MIXTURE.

EXPERIMENT 10.

1. Pour two or three cubic centimeters of bisulphide of carbon on a little powdered roll-sulphur in a dry test-tube.

Does the sulphur dissolve?

2. Treat iron filings in the same way.

Does the iron dissolve?

3. Now treat a small quantity of the mixture prepared in Experiment 9 with bisulphide of carbon. After the sulphur is dissolved pour off the solution in a good-sized watch-glass and let it stand. Examine what is left in the test-tube.

Is it iron?

4. After the liquid has evaporated examine what is left on the watch-glass.

Is it sulphur?

A MECHANICAL MIXTURE CONVERTED INTO A CHEMICAL COMPOUND BY HEAT.

EXPERIMENT 11.

1. Mix three grams of finely powdered roll-sulphur with the same weight of fine wrought-iron filings or powdered iron to be had of the druggist. Put the mixture in a *dry* test-tube. Heat gently and note the changes.

Is there any evidence that heat is caused by the change?

2. After the action is over and the tube has cooled down, break it and put the contents in a small dry mortar.

Does the mass look like the mixture of sulphur and iron with which you started?

3. Examine with a microscope or magnifying-glass; with carbon disulphide; with a magnet.

Compare your observations with those made on the mixture used in the preceding experiment.

What conclusions does this experiment lead you to?

EXPERIMENT 12.

1. In a small porcelain crucible arranged as shown in Fig. 3 put a small piece of lead. Heat by means of a laboratory burner, and notice the changes which take place. After the lead is melted stir with a thick iron wire while heating. Continue to heat and stir until the substance is no longer liquid.

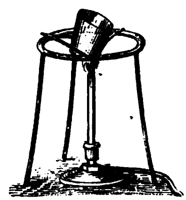

FIG. 3.

What is its appearance now?

2. Let it cool.

Is it lead?

What difference is there between the action in this case and in the case of melting ice and cooling the water down again?

Which is chemical action and which physical action? Why?

EXPERIMENT 13.

Heat a piece of zinc in the same way as you heated lead in the last experiment.

What changes take place?

EXPERIMENT 14.

Heat a piece of tin in the same way as the metals were heated in the last two experiments.

What changes take place?

EXPERIMENT 15.

Repeat Experiments 12, 13, and 14, adding in each case enough borax to form a complete cover to the metal after the borax and the metal are melted. Do not stir the substances.

Do the metals melt?

Are they changed to powders?

How do you explain the difference?

Experiment 16.

1. Fix a short bit of candle on a large flat cork or a block of wood. Light the candle and place it with the block on water contained in a pail or some other appropriate vessel. Place over it a good-sized glass vessel, either a wide-mouthed bottle or a fruit-jar, as represented in Fig. 4, so that the candle and cork are

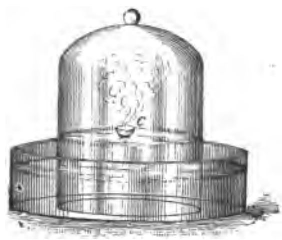

Fig. 4.

in the glass vessel and the mouth of the vessel is beneath the surface of the water. Hold it in this position for a few minutes and observe what takes place.

Does the candle continue to burn?

Is all the air contained in the vessel used up when the candle goes out?

EXPERIMENT 16—(*Continued*).

2. Try the experiment a second time, and when the candle is nearly out raise the glass vessel so that air can get in.

Does this make any difference?

What difference?

What do these experiments prove?

3. After the candle has gone out place your hand or a ground-glass plate over the mouth of the vessel under water, and turn the vessel mouth upwards.

FIG. 5.

Insert into it a lighted candle on a wire as shown in Fig. 5.

Is the gas contained in the vessel ordinary air?

How do you know?

Experiment 17.

Gases which are not soluble in water are collected over water. For this purpose the vessel to be filled with the gas is filled with water and turned upside down with the mouth under water, as shown in Fig. 6.

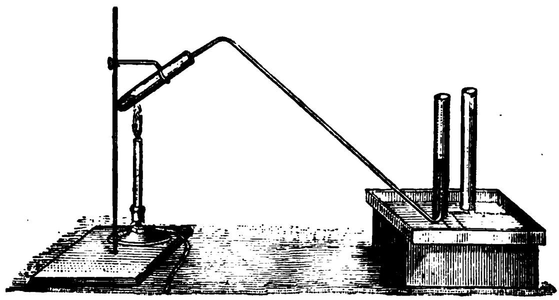

Fig. 6.

The vessels remain filled with water. Why?

2. Try this with test-tubes.

3. Now put the end of a glass tube under the mouth of one of the test-tubes thus filled, and blow gently through it.

What do you notice?

What is in the tube after the water is out of it?

Where did this come from?

OXYGEN.

EXPERIMENT 18.*

1. Heat a little mercuric oxide (red oxide of mercury) in a hard-glass tube arranged as shown in Fig. 6. The tube should be fitted with a good cork with one hole in it through which passes a small glass tube. The end of this smaller glass tube should be bent slightly upward as shown.

What changes take place?

2. Collect some of the gas in test-tubes, and by means of a small stick with a spark on it determine whether the gas is ordinary air or not.

Compare this experiment with Experiment 2.

What have you learned from this experiment that you did not learn from Experiment 2?

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* It was by means of this experiment that oxygen was discovered by Priestley and Scheele in 1774. The discovery was one of the highest importance for chemistry.

Experiment 19.

1. Arrange an apparatus as shown in Fig. 7. *A*

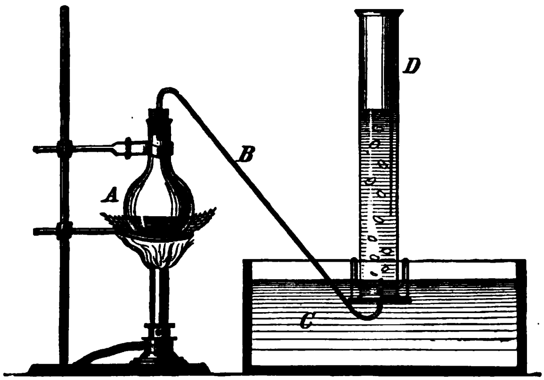

Fig. 7.

represents a flask of about 100 c.cm. capacity. By means of a good-fitting rubber stopper one end of the bent glass tube *B* is connected with it, and the other end, which should turn upward slightly, is placed under the surface of the water in *C*.

EXPERIMENT 19—(*Continued*).

2. In *A* put 4 to 5 grams * (about an eighth of an ounce) potassium chlorate, and gently heat by means of a lamp.

3. When gas comes off freely bring the inverted cylinder *D* filled with water over the end of the tube, and let the bubbles of gas rise in the cylinder.

4. Examine the gas by placing a glass plate over the mouth of the vessel containing it and inverting it.

5. Insert into it a stick with a spark on its end.

What takes place?

Is the gas contained in the vessel ordinary air?

Write the equation expressing the chemical change.

What caused the chemical change in this case?

In what respects is this chemical change like that in the last experiment?

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* A smaller quantity of potassium chlorate may be used in a test-tube arranged as in Fig. 6.

OXYGEN.

EXPERIMENT 20.

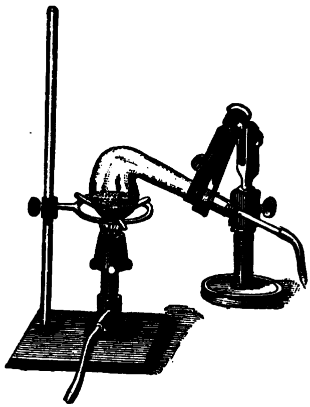

FIG. 8.

Mix 25 to 30 grams * (or about an ounce) of potassium chlorate with an equal weight of *coarsely* powdered manganese dioxide in a mortar. Heat the mixture † in a glass retort arranged as shown in Fig. 8, and collect the gas by displacement of water in appropriate vessels—cylinders, bell-glasses, bottles with wide mouths, etc.

---

* Smaller vessels may be used for collecting the gas, and 5 to 10 grams of potassium chlorate and an equal weight of manganese dioxide. Instead of a retort a good-sized test-tube may be used.

† Black oxide of manganese is sometimes adulterated with other substances, and when heated with potassium chlorate it may then give rise to explosions. It should be tested before using by mixing a very small quantity with potassium chlorate and heating in a dry test-tube. If the decomposition takes place quietly the substance may be used for the preparation of oxygen.

EXPERIMENT 21.

Turn three of the bottles containing oxygen with the mouth upward, leaving them covered with glass plates. Into one introduce a little sulphur in a so-called deflagrating-spoon, which is a small cup of iron or brass attached to a stout wire which passes through a round metal plate, usually of tin (see Fig. 9). In another put a little charcoal (carbon), and in a third a piece of phosphorus * about the size of a pea. Let them stand quietly and notice what changes, if any, take place.

Does oxygen at ordinary temperature act readily upon the substances used in the experiments?

---

* Phosphorus should be handled with great care. It is always kept under water, usually in the form of sticks. When a small piece is wanted, take out a stick with a pair of forceps, and put it under water in an evaporating-dish. *While it is under the water* cut off a piece the size wanted. Take this out by means of a pair of forceps, lay it for a moment on a piece of filter-paper, which will absorb most of the water; then quickly put it in the spoon.

EXPERIMENT 22.

1. In a deflagrating-spoon set fire to a little sulphur and let it burn *in the air.* Notice whether it burns with ease or with difficulty. Notice the odor of the fumes which are given off.

FIG. 9.

2. Now set fire to another small portion and introduce it in a spoon into one of the vessels containing oxygen, as shown in Fig. 9.

Does the sulphur burn more readily in the oxygen or in the air?

3. Notice the odor of the fumes given off.

Is it the same as that noticed when the burning takes place in the air?

EXPERIMENT 23.

Perform similar experiments with charcoal.

What takes place?

Explain all that you have seen.

OXYGEN.

EXPERIMENT 24.*

Burn a *small* piece of phosphorus in the air and in oxygen. In the latter case the light emitted from the burning phosphorus is so intense that it is painful to some eyes to look at it. After the burning is over let the vessel stand.

Does it become clear?

What has taken place?

---

* It may be as well for the teacher to perform this experiment. It is simple enough, but phosphorus is a dangerous substance, and the burns caused by it heal with difficulty. The piece of phosphorus burned should be about the size of an ordinary pea. It should be put on a deflagrating-spoon, and this should be fixed in the middle of a rather large glass vessel containing oxygen.

Experiment 25.

Straighten a steel watch-spring * and fasten it in a piece of metal, such as is used for fixing a deflagrating-spoon in an upright position; wind a little thread around the lower end, and dip it in melted sulphur. Set fire to the sulphur, and insert the spring into a vessel containing oxygen.

Describe all that takes place.

When iron is exposed to the air what is the color of the substance formed on its surface?

Does this substance suggest anything formed in the experiment?

How do you explain the resemblance?

---

* Old watch-springs can generally be had of any watch maker or mender for the asking. A spring can be straightened by unrolling it, attaching a weight, and suspending the weight by the spring. The spring is then heated up and down to redness with the flame of a laboratory burner or spirit-lamp.

NITROGEN.

Experiment 26.

1. Place a wide-mouthed jar over water in a larger vessel of water. In the middle of a flat cork about three inches in diameter fasten a small porcelain crucible, and float this on the water in the trough. Put in it a piece of phosphorus about twice the size of a pea, and set fire to the phosphorus. Quickly place the jar over it on a support which will prevent the jar from sinking more than an inch or two in the water.

Why is air at first forced out of the vessel?

Why does the water afterward rise in the vessel?

After the burning has stopped and the vessel has cooled down, about what proportion of the air is left in the vessel?

2. Cover the mouth of the jar with a glass plate and turn it mouth upward. Try the effect of introducing one after the other several burning bodies into the gas, as, for example, a candle, a piece of sulphur, etc.

Explain all that you have seen.

WATER.

Experiment 27.

1. In a dry tube heat gently a small piece of wood. What evidence do you obtain that water is given off?

2. Do the same thing with a piece of fresh meat. Is water formed in this case?

CRYSTALS AND WATER OF CRYSTALLIZATION.

Most substances which dissolve in water are more soluble in hot water than in cold. In a hot solution there may therefore be more of a substance than can remain in solution when cool. On cooling the substance will in many cases be deposited in regular-shaped masses which are called crystals.

Experiment 28.

1. Dissolve some ordinary alum in water (3–4 ounces alum to 100 c.cm. water) by the aid of heat. Filter through a plaited filter and allow the filtered solution to cool.

What takes place?

2. Pour off the liquid above and place a few of the crystals on a piece of dry filter-paper. After the water is all absorbed from them and they appear dry, put them in a dry test-tube and heat gently.

What evidence have you that water is contained in the crystals?

Experiment 29.

Perform a similar experiment with some gypsum, which is the natural substance from which "plaster of Paris" is made.

What evidence have you that water is contained in this substance?

What is the substance which is left behind after the heating?

Experiment 30.

1. Heat a few small crystals of copper sulphate ("blue vitriol").

What change besides the escape of water do you notice?

What is the color of the powder which is left behind?

2. Dissolve this powder in a little water in a test-tube.

What is the color of the solution?

3. Evaporate off some of the water and let the solution cool. Repeat this, if necessary, until on cooling crystals are deposited.

What is the color of the crystals?

Do these crystals in any way suggest those with which you started?

EFFLORESCENT COMPOUNDS.

Experiment 31.

Select a few crystals of sodium sulphate or Glauber's salt which have not lost their lustre. Put them on a watch-glass, and let them lie exposed to the air for an hour or two.

What evidence have you that change takes place?

DELIQUESCENT COMPOUNDS.

Experiment 32.

Expose a few pieces of calcium chloride to the air. Calcium chloride was the product obtained in Experiment 3. If there is none in the laboratory make some.

What change takes place when the substance is exposed for some time to the air?

DECOMPOSITION OF WATER.

EXPERIMENT 33.

Throw a small piece of sodium* on water. While it is floating on the surface apply a lighted match to it.

What takes place?

What causes the flame?

Why is the flame yellow?

---

* The metals sodium and potassium are kept under kerosene oil. When a small piece is wanted, take out one of the larger pieces from the bottle, roughly wipe off the oil with filter-paper, and cut off a piece the size needed. It is not advisable to use a piece larger than a small pea.

HYDROGEN.

EXPERIMENT 34.

1. In a cylinder or test-tube put a few pieces of *granulated zinc*, and pour upon it enough ordinary hydrochloric acid to cover it.

What do you notice?

2. After the action has continued for a minute or two, apply a lighted match to the mouth of the vessel.

What takes place?

3. Try the same experiments using sulphuric acid which has been diluted with six times its volume of water.*

What is the result?

What is the gas given off?

---

* To dilute ordinary concentrated sulphuric acid with water, the acid should be poured *slowly* into the water while the mixture is constantly stirred. If the water is poured into the acid, the heat evolved at the places where the two liquids come in contact with each other may be so great as to convert the water into steam and cause the strong acid to spatter.

Experiment 35.

For the purpose of collecting hydrogen the gas should be evolved from a bottle with two necks called a Wolff's flask (see Fig. 10), or a wide-mouthed bottle in which is fitted a cork with two holes (see Fig. 11).

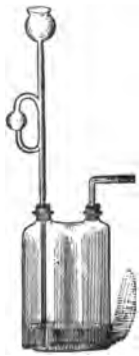

Fig. 10.

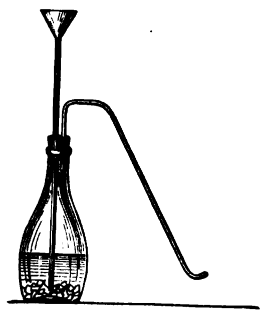

Fig. 11.

Put a small handful of granulated zinc* into the bottle and pour upon it enough *cooled* dilute sulphuric acid (1 volume concentrated acid to 6 volumes of water) to cover it. Collect by displacement of water as in the case of oxygen. Should the action become slow add a little more of the dilute acid. Fill several cylinders and bottles with the gas.

* Some zinc, particularly that which is pure, does not act readily upon acids. Whether the action is taking place freely or not can be seen by the effervescence in the flask and by the rate at which bubbles of gas appear at the end of the delivery tube when this is placed under water. If the action is slow, *wait longer* before collecting it and before setting fire to it. It is better not to use zinc which acts slowly.

EXPERIMENT 36.

Place a vessel containing hydrogen with the mouth upward and uncovered. In a short time examine the gas and see whether it is hydrogen.

EXPERIMENT 37.

Gradually bring a vessel containing hydrogen with its mouth upward below an inverted vessel containing air, in the way shown in Fig. 12.

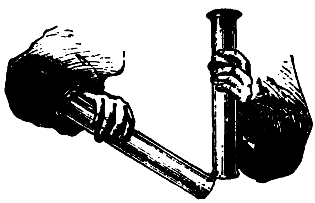

FIG. 12.

Is there hydrogen in the vessel with the mouth upward?

Is there hydrogen in the other vessel?

EXPERIMENT 38.

Soap-bubbles filled with hydrogen rise in the air. The experiment is best performed by connecting an ordinary clay pipe by means of a piece of rubber tubing with the exit-tube of a gasometer filled with hydrogen. Small balloons of collodion are also made for showing the lightness of hydrogen. Large balloons are always filled with hydrogen or some other light gas. Some kinds of illuminating-gas are rich in hydrogen, and may therefore be used for the purpose.

Experiment 39.

1. Hold a wide-mouthed bottle or cylinder filled with hydrogen with the mouth downward. Insert into the vessel a lighted taper held on a bent wire, as shown in Fig. 13.

Fig. 13.

What do you observe?

What burns?

Does the taper continue to burn?

2. Withdraw the taper and hold the wick for a moment in the flame at the mouth of the cylinder, then withdraw it entirely. Put it back again in the hydrogen.

Does hydrogen support combustion?

Does it burn?

3. Try similar experiments with a piece of wood.

Experiment 40.

1. To a little ammonium chloride on a watch-glass add a few drops of a strong solution of caustic soda, and notice the odor of the gas given off.

2. Do the same thing with caustic potash.

3. Mix small quantities of quicklime and ammonium chloride in a mortar, and notice the odor.

Has ammonium chloride this odor?

What is the substance with the odor?

How is it formed in the experiments?

Experiment 41.

1. Arrange an apparatus as shown in Fig. 14. In

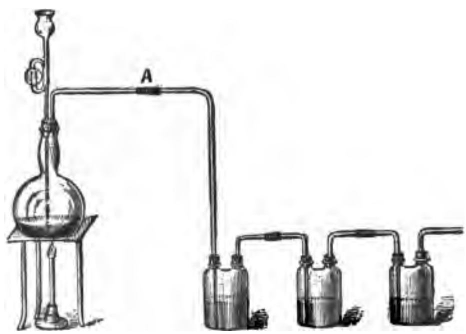

Fig. 14.

the flask put a mixture of 50 grams slaked lime and 25 grams ammonium chloride. Heat on a sand-bath.

Experiment 41—(*Continued*).

After the air is driven out, the gas will be completely absorbed by the water in the first Wolff's flask.

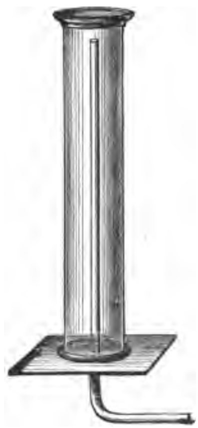

Fig. 15.

2. Disconnect at *A*, and connect with another tube bent upward. Collect some of the escaping gas by displacing air, *placing the vessel with the mouth downward*, as the gas is much lighter than air. The arrangement is shown in Fig. 15. The vessel in which the gas is collected should be dry, as water absorbs ammonia very readily. Hence also the gas cannot be collected over water.

3. In the gas which you have collected introduce a burning stick or taper.

Does the gas burn?

Does it support combustion? *In working with the gas great care must be taken to avoid breathing it in any quantity.*

4. After enough has been collected, connect the delivery-tube again with the series of Wolff's flasks, and pass the gas through the water as long as it is given off.

NITRIC ACID.

EXPERIMENT 42.

Arrange an apparatus as shown in Fig. 16. In the

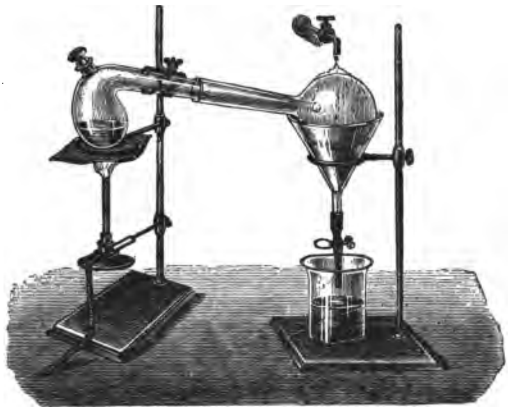

FIG. 16.

retort* put 15 grams sodium nitrate (Chili saltpeter) and 9 grams concentrated sulphuric acid. Heat gently.

What takes place?

What is the color due to?

---

* This experiment may be simplified by using a test-tube as a receiver. It can be kept cool by immersing the lower part in cold water contained in an evaporating-dish or beaker.

NITRIC ACID.

EXPERIMENT 43.

In test-tubes try the action of a little of the liquid you obtained in the last experiment on small pieces of copper, zinc, iron, lead, tin.

Describe the results obtained.

EXPERIMENT 44.

1. Dissolve a few pieces of copper-foil in ordinary commercial nitric acid diluted with about half its volume of water. The operation should be carried on in a good-sized flask and either out of doors or under a good hood.

What action takes place?

After it is over what is the appearance of the liquid in the flask?

2. Pour it out and evaporate to crystallization. Compare the substance thus obtained with copper nitrate.—Heat specimens of each.—Treat small specimens with sulphuric acid.

Do the substances appear to be identical?

What reasons have you for considering them identical?

NITROUS OXIDE.

EXPERIMENT 45.

1. In a retort heat 10 to 15 grams crystallized ammonium nitrate until it has the appearance of boiling. Do not heat higher than is necessary to secure a regular evolution of gas. Connect a wide rubber tube directly with the neck of the retort, and collect the gas over water, as in the case of oxygen.

What chemical change takes place?

2. Insert into the gas a piece of burning wood, and a candle.

Explain what takes place.

EXPERIMENT 46.

Arrange an apparatus as shown in Fig. 17. In the flask put a few pieces of copper-foil. Cover this with water. Now *slowly* add ordinary concentrated nitric acid. When enough acid has been added gas will be given off. If the acid is added quickly it not infrequently happens that the evolution of gas takes place too rapidly, so that the liquid is forced out of the flask through the funnel-tube. *This can be avoided by not being in a hurry.*

FIG. 17.

What is the color of the gas in the flask at first?

What is it after the action has continued for a short time?

Collect over water two or three vessels full.

EXPERIMENT 47.

1. Turn one of the vessels containing colorless nitric oxide with the mouth upward and uncover it.

What takes place?

Explain the appearance of the colored gas in Experiment 46, and the fact that it afterward disappeared.

What was in the vessel at the beginning of the operation?

Do not inhale the gas. Perform the experiments with nitric oxide where there is a good draught.

2. Into one of the vessels containing nitric oxide insert a burning candle.

Does the gas burn?

Does it support combustion?

CHLORINE.

Experiment 48.

1. In a flask put about 50 grams ($1\frac{1}{2}$ to 2 ounces) of black oxide of manganese. Pour upon it enough ordinary concentrated hydrochloric acid to cover it completely. Arrange the apparatus as shown in Fig. 18. Heat gently in a sand-bath.

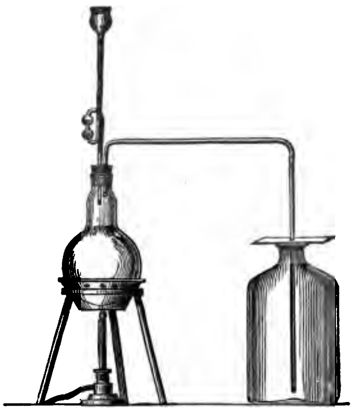

Fig. 18.

What is given off?

2. Collect six or eight *dry* cylinders or bottles full of chlorine by letting the delivery-tube extend to the bottom of the collecting vessel and covering the mouth of the vessel with a piece of paper. You can see when the vessel is full by the color of the gas.—*The experiments with chlorine should be carried on in a place where the draught is good. Do not inhale the gas.*

CHLORINE.

Experiment 49.

1. Into one of the vessels containing chlorine introduce a little finely powdered antimony.

What takes place?

In what respects is this experiment like the one in which iron was burned in oxygen?

2. Into a second vessel put a few pieces of copper-foil which you have heated.

What takes place?

3. Into a third vessel put a piece of paper with writing on it, some flowers, and some pieces of colored calico which you have *moistened.*

What takes place?

4. Into a fourth vessel put a *dry* piece of the same calico used in 3.

What difference is there in the action of the chlorine on the dry and on the moist calico?

Write a full account of the method you have used in preparing chlorine, and of the results obtained in the experiments with chlorine.

Compare chlorine with hydrogen and with oxygen.

HYDROCHLORIC ACID.

Experiment 50.

Pour 2 or 3 c.cm. concentrated sulphuric acid on a gram or two of common salt in a test-tube.

What takes place?

Is a gas given off?

What is its appearance?

Experiment 51.

Arrange an apparatus as shown in Fig. 14, page 72. Weigh out, separately, 50 grams common salt, 50 grams concentrated sulphuric acid, and 10 grams water. Mix the acid and water, taking the usual precautions (see note p. 64). Let the mixture cool down to the ordinary temperature, and then pour it on the salt in the flask.

2. Heat the flask *gently*. Conduct the gas at first through water contained in two or three Wolff's bottles until what passes over is completely absorbed in the first Wolff's bottle.

Why does the gas at first bubble through the water in all the bottles?

What besides the visible substances is contained in all the vessels at the beginning of the experiment?

3. After the gas has passed for 10 to 15 minutes disconnect at *A* (see Fig. 14).

What appears?

"Blow your breath" on the gas coming out of the tube, taking care not to direct the gas towards your face, and not to get too near it.

What effect has this?

4. Apply a lighted match to the end of the tube.

Does the gas burn?

Does the match continue to burn?

5. Collect some of the gas in a dry cylinder as in the case of chlorine.

What observation have you already made which shows that you cannot collect this gas in the same way that you collected hydrogen and oxygen?

In collecting chlorine and hydrochloric acid the vessels must stand mouth upward. Are these gases heavier or lighter than air?

Has the gas any color?

Is it transparent?

6. Insert a burning stick or candle in the cylinder filled with the gas.

Does the gas support combustion?

7. Connect the generating-flask again with the bottles containing water, and let the action continue until no more gas comes over.

Express the complete change by an equation.

What is left in the flask?

8. After the flask has cooled down pour water on the contents, and, when the substance is dissolved, filter and evaporate the solution to such a concentration that, on cooling, the solid product is deposited. Pour off the liquid, and dry the solid substance by placing it upon folds of filter-paper.

9. Compare the substance with the common salt which you put into the flask at the beginning of the experiment.—Heat a small piece of each in a dry tube.—Treat a small piece of each in a test-tube with a little concentrated sulphuric acid.

What differences do you observe between them?

If in the experiment you should recover all the sodium sulphate formed, how much would you get?

10. Put about 50 c.cm. of the liquid from the first Wolff's bottle in a porcelain evaporating-dish, and heat over a small flame just to boiling.

Is hydrochloric acid given off?

Can all the liquid be driven off by boiling?

11. Try the action of some of the liquid from the first Wolff's bottle on some iron filings in a test-tube.

Is a gas given off?

What is it?

12. Add some of the liquid to a little granulated zinc in a test-tube.

What gas is given off?

13. Add some to a little manganese dioxide in a test-tube.

What is given off?

How do you know?

14. Add ten or twelve drops to 2 or 3 c.cm. water in a clean test-tube. Taste the solution.

How would you describe the taste?

15. Add a drop or two of a solution of *blue litmus*,* or put into it a piece of paper colored blue with litmus.

What change takes place?

16. To the solution to which litmus has been added add a drop or two of caustic soda or ammonia.

What change takes place?

Write a full account of all you have done since you started with the sulphuric acid and common salt, and be sure that your account contains answers to all the questions which have been asked.

---

* Litmus is a vegetable substance prepared for use as a dye.

NEUTRALIZATION—FORMATION OF SALTS.

EXPERIMENT 52.

1. Dissolve 5 grams caustic soda in 50 grams c.cm. water. Add hydrochloric acid slowly, examining the solution from time to time by means of a piece of paper colored blue with litmus. As long as the solution is alkaline it will cause no change in the color of the paper. The instant it passes the point of neutralization it changes the color of the paper red. When this point is reached, evaporate the water on a water-bath to complete dryness, and see what is left. Taste the substance.

Has it an acid taste?

Does it suggest any familiar substance?

If it is common salt or sodium chloride, how ought it to conduct itself when treated with sulphuric acid?

Does it conduct itself in this way?

Is the substance an alkali?

Is it an acid?

Is it neutral?

Write the equation representing the action.

2. Perform the same experiment as under 1, using nitric acid instead of hydrochloric acid.—Compare the product with sodium nitrate.

Heat a small specimen of each in a tube closed at one end.

What takes place?

Treat a small specimen of each with a little sulphuric acid in test-tubes.

What takes place?

Write the equation representing the action.

Write an account of the process of neutralization.

CHARCOAL.

EXPERIMENT 53.

1. Make a filter of bone-black by fitting a paper filter into a funnel 8 to 10 mm. (3 to 4 inches) in diameter at its mouth. Half fill this with bone-black. Pour a dilute solution of indigo* through the filter.

What effect does this have on the color of the solution?

2. Do the same thing with a dilute solution of litmus.—If the color is not completely removed by one filtering, filter the solutions again.

3. The color can also be removed from solutions by putting some bone-black into them and boiling for a time. Try this with half a liter each of the litmus and indigo solutions used in the first part of the experiment. Use about 4 to 5 grams bone-black in each case. Shake the solutions frequently while heating.

---

* Prepared by treating powdered indigo for some time with warm concentrated sulphuric acid and diluting with much water.

CARBON.

EXPERIMENT 54.

1. Mix together 2 or 3 grams powdered copper oxide, CuO, and about one tenth its weight of powdered charcoal; heat in a tube to which is fitted an outlet tube, as shown in Fig. 19. Pass the gas which is given off into clear lime-water contained in a test-tube.

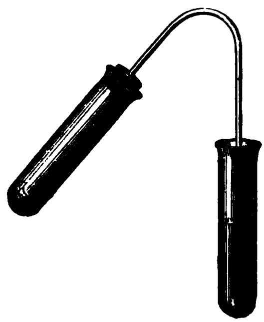

FIG. 19.

Is it carbon dioxide?

What evidence have you that oxygen has been extracted from the copper oxide?

What is the appearance of the substance left in the tube?

Does it suggest the metal copper?

2. Treat a little with strong nitric acid.

What should take place if the substance is metallic copper? (See Experiment 44.)

What does take place?

What is the reaction which takes place between the copper oxide and the charcoal? Write the equation.

Compare the action of hydrogen with that of carbon on copper oxide.

In what respects are they alike, and in what respects do they differ?

EXPERIMENT 55.

Perform an experiment like the last with a little *white arsenic* in a small glass tube closed at one end. Take about equal parts by weight of charcoal and arsenic.

Explain what you see.

Compare the action in this case with that in Experiment 54.

MARSH GAS.

EXPERIMENT 56.

Mix 5 grams dry sodium acetate, 5 grams potassium hydroxide, and 7½ grams quicklime. Heat in a retort. Collect over water as in making nitrous oxide.

Does the gas burn?

Does it give light in burning?

CARBON DIOXIDE.

EXPERIMENT 57.

FIG. 20.

Blow through some lime-water by means of an apparatus arranged as shown in Fig 20.

What evidence have you that your lungs give off carbon dioxide?

EXPERIMENT 58.

1. In different test-tubes containing a little sodium carbonate add dilute hydrochloric, sulphuric, nitric, and acetic acids.

What takes place?

Is a gas given off?

2. Pass it through lime-water.

Is it carbon dioxide?

3. Perform the same experiment with small pieces of marble.

What gas is given off?

What conclusions can you draw from these observations?

CARBON DIOXIDE.

Experiment 59

1. Arrange an apparatus as shown in Fig. 21. In the flask put some pieces of marble, and pour ordinary hydrochloric acid on it. Collect the gas by displacement of air, placing the vessel with the mouth upward. Fill several cylinders or bottles with the gas.

Fig. 21.

2. Into one introduce a lighted candle, and afterwards a burning stick.

What takes place?

3. With another proceed as if pouring water from it. Pour the invisible gas upon the flame of a burning candle.

4. Pour some of the gas from one vessel to another, and show that it has been transferred.

5. Balance a beaker on a good-sized scales, and pour carbon dioxide into it.

Explain all that you have done, giving an account of the properties of carbon dioxide as you have observed them in the above experiments.

CARBONATES.

Experiment 60.

1. Pass carbon dioxide into a solution of caustic potash until it will absorb no more.

2. Add acid to some of the solution thus obtained.

What gas is given off when the acid is added?

How do you know?

Write the equations expressing the reactions which take place on passing the carbon dioxide into the caustic potash solution, and on adding an acid to the solution.

CARBON DIOXIDE.

Experiment 61.

1. Pass carbon dioxide into 50 to 100 c.cm. clear lime-water.

2. Filter off the white insoluble substance.

3. Try the action of a little acid on it.

What evidence have you that it is calcium carbonate?

How could you easily distinguish between lime-water and a solution of caustic potash?

Experiment 62.

1. Pass carbon dioxide first through a little water to wash it, and then into 50 to 100 c.cm. clear lime-water.

2. After the solution has become clear, heat it.

What has taken place?

CARBON MONOXIDE (CARBONIC OXIDE).

EXPERIMENT 63.

Put 10 grams crystallized oxalic acid and 50 to 60 grams concentrated sulphuric acid in an appropriate-sized flask. Connect with two Wolff's flasks containing caustic-soda solution. Heat the contents of the flask gently. Collect some of the gas over water. Set fire to the same, and notice the characteristic blue flame.

What is formed when the gas burns?

EXPERIMENT 64.

Pass carbon monoxide over some heated copper oxide contained in a hard glass tube.

Is the copper oxide reduced?

How do you know?

Is carbon dioxide formed?

What evidence have you?

Was the carbon monoxide free from carbon dioxide?

If not, what evidence have you that carbon dioxide is formed in this experiment?

FLAMES.

Experiment 65.

1. Light a Bunsen burner. Bring down upon the flame a piece of brass or iron wire gauze.

Does the flame pass through the gauze?

2. Apply a light above the gauze and above the outlet of the burner.

Is there any gas unburned above the gauze?

Why does the flame not pass through the gauze?

3. Turn on a Bunsen burner. Do not light the gas. Hold a piece of wire gauze about one and a half to two inches above the outlet. Apply a lighted match above the gauze.

Where is the flame?

What is below the gauze?

Prove it.

What is the principle upon which the Davy safety-lamp is constructed?

For what is it used?

BROMINE AND HYDROBROMIC ACID.

EXPERIMENT 66.

Mix together about a gram of potassium bromide and two grams of manganese dioxide. Pour upon the mixture in a good-sized test-tube sufficient dilute sulphuric acid to cover it. Heat gently.

What do you observe?

Perform this experiment where there is a good draught.

EXPERIMENT 67.

1. In a test-tube put a few crystals of potassium bromide. Pour on them a few drops of concentrated sulphuric acid.

What do you see?

2. Treat a few crystals of potassium or sodium chloride in the same way.

What difference is there between the two cases?

Explain the difference.

IODINE AND HYDRIODIC ACID.

EXPERIMENT 68.

Mix about 1 gram potassium iodide with about twice its weight of manganese dioxide. Treat with a little sulphuric acid in a test-tube. Heat gently.

What takes place?

EXPERIMENT 69.

Make solutions of iodine in water, in alcohol, and in a water solution of potassium iodide. Use small quantities in test-tubes.

Is iodine soluble in water?

Is it soluble in alcohol?

Is it soluble in a solution of potassium iodide?

IODINE AND HYDRIODIC ACID.

EXPERIMENT 70.

1. Make some starch-paste by covering a few grains of starch in a porcelain evaporating-dish with cold water, grinding this to a paste, and pouring 200–300 c.cm. boiling hot water on it.

2. After cooling add a little of this paste to a dilute water solution of iodine.

What change takes place?

3. Now add a little of the paste to a diluted water solution of potassium iodide.

Is there any change of color?

4. Add a drop or two of a solution of chlorine in water.

What takes place?

Explain what you have seen.

Does chlorine alone form a blue compound with starch?

IODINE AND HYDRIODIC ACID.

EXPERIMEMT 71.

Treat a few small crystals of potassium iodide with sulphuric acid.

What do you notice?

Compare with the results obtained when potassium bromide and sodium chloride are used.

HYDROFLUORIC ACID.

Experiment 72.

In a lead or platinum vessel put a few grams (5–6) of powdered fluor-spar, and pour on it enough concentrated sulphuric acid to make a thick paste. Cover the surface of a piece of glass with a thin layer of wax or paraffin, and through this scratch some letters or figures, so as to leave the glass exposed where the scratches are made. Put the glass with the waxed side downward over the vessel containing the fluor-spar, and let it stand for some hours. Then take off the glass and scrape off the coating.

What chemical changes have taken place in this experiment?

What is the change in the glass called?

Suppose marks had been made on the glass by a diamond, would the change be chemical or physical?

SULPHUR.

EXPERIMENT 73.

Dissolve 2 to 3 grams roll sulphur in 5 to 10 c.cm. carbon disulphide. Put the solution in a shallow vessel, and allow the carbon disulphide to evaporate by standing in the air.

What is the appearance of the crystals?

Are they dark yellow or bright yellow?

Are they brittle or elastic?

State in tabular form the properties of the two allotropic forms of sulphur.

EXPERIMENT 74.

In a wide test-tube heat some sulphur to boiling. Introduce into it small pieces of copper-foil or sheet-copper. Or hold a narrow piece of sheet-copper so that the end just dips into the boiling sulphur.

What evidence have you that action takes place?

Compare the chemical action in this case with that which takes place when copper-foil is put into chlorine.

HYDROGEN SUDPHIDE (SULPHURETTED HYDROGEN).

EXPERIMENT 75.

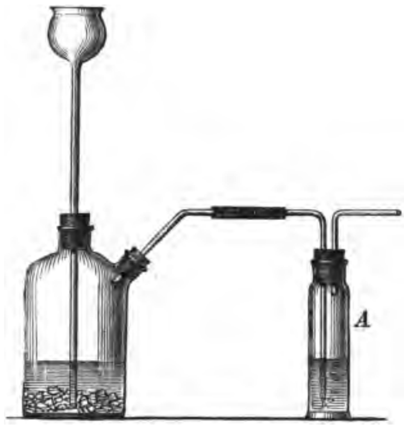

FIG. 22.

Arrange an apparatus as shown in Fig. 22. Put a small handful of sulphide of iron, FeS, in the flask, and pour cold, *dilute* sulphuric acid upon it.

1. Pass the gas through a little water contained in the wash-cylinder *A*. Pass some of the gas into water. Is the gas soluble in water?

2. Collect some of the gas by displacement of air as in the case of chlorine and hydrochloric acid.

3. Set fire to some of the gas contained in a cylinder. What products are formed?

Hydrochloric acid, water, ammonia, marsh gas, and hydrogen sulphide are all compounds of hydrogen. Compare them with special reference to their conduct towards oxygen.

HYDROGEN SULPHIDE.

EXPERIMENT 76.

Pass hydrogen sulphide successively through solutions containing a little *lead nitrate*, *zinc sulphate*, and *arsenic* prepared by dissolving a little white arsenic, or *arsenic trioxide*, As_2O_3, in dilute hydrochloric acid.

What do you observe in each case?

SULPHUR DIOXIDE.

Experiment 77.

1. Put eight or ten pieces of sheet-copper, one to two inches long and about half an inch wide, into a 500-c.cm. flask; pour 15 to 20 c.cm. concentrated sulphuric acid upon it. Heat gently. The moment the gas begins to come off, lower the flame, and keep it at such a height that the evolution is regular and not too active.

2. Pass some of the gas into a bottle containing water. Collect a vessel full by displacement of air. (It is more than twice as heavy as air.)

3. See whether the gas will burn or support combustion.

What properties has the gas?

Is it colored?

Is it transparent?

Has it an odor?

Does it burn?

Does it support combustion?

Is it soluble in water?

In what experiment already performed was this gas formed?

Experiment 78.

Burn a little sulphur in a porcelain crucible under a bell-jar. Place over the crucible on a tripod some flowers.

What change takes place in the flowers?

Compare the action with the action of chlorine.

Does sulphur dioxide act in the same way that chlorine does?

PHOSPHORUS.

EXPERIMENT 79.

Bring together in a porcelain crucible or evaporating-dish a little phosphorus and iodine.

What takes place?

What is the cause of the light and heat?

Compare the action of phosphorus towards iodine with its action towards oxygen.

What other examples have you had of the direct combination of two elements by simple contact?

What examples have you had of direct combination of two elements at elevated temperature?

Experiment 80.

Arrange an apparatus as shown in Fig. 23. Put some granulated zinc in the flask and pour dilute sulphuric acid on it. When the air is all out of the vessel and the hydrogen is lighted, slowly add a little of a solution of arsenic oxide, As_2O_3, in dilute hydrochloric acid.

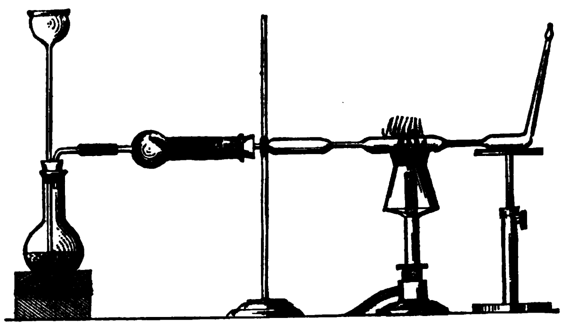

Fig. 23.

What change takes place in the flame?
Is the color changed?
Are fumes given off? (See Experiment 83.)

ARSENIC.

EXPERIMENT 81.

1. Into the flame of the burning hydrogen and arsine produced in the last experiment introduce a piece of porcelain, as the bottom of a small porcelain dish or crucible, or a bit of a broken plate, and notice the appearance of the spots.

2. Heat by means of a Bunsen burner the tube through which the gas is passing, which should be of hard glass.

Explain what you have seen?

EXPERIMENT 82.

Mix together about equal small quantities of arsenic oxide and finely-powdered charcoal. Heat the mixture in a small dry tube of hard glass, closed at one end.

What change takes place?

What is this kind of action called?

ANTIMONY.

Experiment 83.

1. Make some stibine, using the same kind of apparatus as that for making arsine. Instead of a solution of arsenic use a solution of tartar emetic, which contains antimony.

What differences, if any, do you notice between what takes place in this case and what you saw in Experiment 80?

2. Introduce a piece of porcelain in the flame and notice the deposit or antimony spot.

Compare the spots with those formed with arsenic.

Is there any difference in the appearance?

Heat the porcelain on which the spots are and notice whether any change takes place.

POTASSIUM.

Experiment 84.

1. Treat two or three pounds of wood-ashes with water. Filter off the solution, and examine it by means of red litmus-paper.

Is the solution alkaline?

2. Examine some potassium carbonate.

Does its solution act in the same way?

3. Evaporate to dryness the solution obtained from the wood-ashes. Collect the dry residue and treat it in a test-tube with a little dilute hydrochloric acid.

Is a gas given off?

What is it?

Experiment 85.

Throw a small piece of potassium not larger than the size of a pea upon water.

What takes place?

What is the color of the flame?

What difference is there between the action of sodium and of potassium on water?

Is the solution after the action alkaline?

Why?

POTASSIUM.

Experiment 86.

1. Examine a bottle of crystallized potassium iodide. Taste a little. Dissolve some in water.

2. Add some iodine to this solution.

Does the iodine dissolve?

3. Heat a little.

Does the substance contain water of crystallization?

4. Treat a crystal or two with a few drops of concentrated sulphuric acid.

What takes place?

To what is the appearance of violet vapors due? See Experiment 71.

Experiment 87.

1. Dissolve 25 grams potassium carbonate in 250–300 c.cm. water. Heat to boiling in an iron (or silver) vessel, and gradually add slaked lime made from 12–15 grams good quicklime. During the operation the mass should be stirred with an iron spatula.

2. After the solution is cool, draw it off by means of a glass siphon into a bottle. This may be used in experiments in which caustic potash is required.

Explain what has taken place.

Write the equation expressing the chemical change.

What is left in the iron vessel?

Experiment 88.

Mix together 15 grams potassium nitrate and 2.5 grams powdered charcoal. Set fire to the mass.

What is left?

What was given off?

What is gunpowder made of?

What is the cause of its explosive power?

Experiment 89.

1. Prepare some pieces of platinum wire, 8 to 10 cm. long, with a small loop on the end. After thoroughly cleaning them, insert one in a little sodium carbonate, and notice the color it gives to the flame.

2. Try another with potassium carbonate.

3. Try a mixture of potassium carbonate and sodium carbonate.

What is the color of the flame?

Could you tell that potassium is in the mixture by looking at the flame with the naked eye?

4. Look through blue glass at the flame caused by potassium alone; at that caused by sodium alone; and at that caused by potassium and sodium.

Can you tell whether potassium is present or not when you use the blue glass?

SODIUM.

Experiment 90.

What is the principal compound of sodium found in nature?

Given this compound, by what chemical reactions could you get sodium sulphate, sodium carbonate, sodium hydroxide, sodium nitrate?

Starting with 25 grams of the principal natural compound of sodium, and using whatever other substances may be necessary, make some potassium chloride.

AMMONIUM SALTS.

Experiment 91.

1. Place near each other two vessels, one containing a little strong hydrochloric acid, and the other a little strong ammonia.

Explain what you see.

2. Try the same experiment using nitric acid instead of hydrochloric acid.

What takes place?

3. Finally, try the experiment using sulphuric acid and ammonia.

What difference is there between this case and the other two?

How do you explain this?

Experiment 92.

On a piece of platinum-foil or porcelain heat a little ammonium chloride.

What is the result?

What is the difference between this process and the process which we call boiling?

What would happen if a piece of ice were heated to the temperature of boiling water?

CALCIUM.

EXPERIMENT 93.

1. Dissolve 10 to 20 grams of limestone or marble in ordinary hydrochloric acid. Evaporate to dryness. Expose a few pieces of the residue to the air.

Does it become moist?

In what experiments has calcium chloride been used, and for what purposes?

What would happen if sulphuric acid were added to calcium chloride?

2. Try it.

Explain what takes place.

Is the residue soluble or insoluble in water?

CALCIUM.

EXPERIMENT 94.

1. To 40 or 50 grams good quicklime add 100 c.cm. water.

What takes place?

2. Afterwards dilute to 2 to 3 liters and put the whole in a well-stoppered bottle. The undissolved lime will settle to the bottom, and in the course of some hours the solution above will become clear. Carefully pour off some of the clear solution.

What takes place when some of the solution is exposed to the air?

When the gases from the lungs are passed through it?

When carbon dioxide is passed through it?

What takes place when dilute sulphuric acid is added to lime-water?

Is calcium sulphate difficultly or easily soluble in water?

Has lime-water an alkaline reaction?

What reaction would you expect to take place between lime and nitric acid?

EXPERIMENT 95.

1. Heat some powdered gypsum to about 200° in an air-bath.

2. Examine what is left and see whether it will become solid when mixed with a little water so as to form a paste.

3. See whether gypsum itself will act in the same way with water.

Explain what you have done.

COPPER.

EXPERIMENT 96.

1. Into a solution of copper sulphate in water insert a strip of zinc.

Explain what takes place?

Compare the action with that which takes place when zinc acts upon sulphuric acid.

2. Perform a similar experiment, using a strip of sheet-iron instead of zinc.

Compare this with the previous experiment.

EXPERIMENT 97.

1. Add some caustic soda or potash to a small quantity of a cold solution of copper sulphate in a test-tube.

What do you notice?

2. After noticing the appearance of the precipitate first formed, heat.

What change takes place?

Explain this.

Express the chemical change by the proper equation.

SILVER.

EXPERIMENT 98.

1. Dissolve a ten or twenty-five cent piece in dilute nitric acid.

What action takes place?

2. Dilute the solution to 200 to 300 c.cm. with water.

What is the color of the solution?

What does this indicate?

Does this color prove that copper is present?

3. Add a solution of common salt until it ceases to produce a precipitate.

What change takes place?

4. Filter off the white silver chloride and carefully wash with hot water.

5. Dry the precipitate on the filter, by placing the funnel with the filter and precipitate in an air-bath heated to about 110°.

6. Remove the precipitate from the filter and put it into a porcelain crucible. Heat gently with a small flame until the chloride is melted.

7. Cut out a piece of sheet-zinc large enough to cover the silver chloride. Lay it on the silver chloride. Now add a little water and a few drops of dilute sulphuric acid, and let the whole stand for twenty-four hours.

What takes place?

8. Take out the piece of zinc and wash the silver with a little dilute sulphuric acid, and then with water.

9. Dissolve the silver in dilute nitric acid and evaporate to dryness on the water-bath, so that the excess of nitric acid is driven off. Dissolve the residue in water, and put the solution either in a bottle of dark glass or one wrapped in dark paper.

SILVER.

EXPERIMENT 99.

1. To a few cubic centimeters of water in a test-tube add 5 to 10 drops of the solution of silver nitrate just prepared.

2. To this dilute solution add a little of a dilute solution of sodium chloride.

What takes place?

3. Place it aside where the light can shine upon it, and notice the change of color which gradually takes place.

4. In the same way make the bromide by adding potassium bromide, and the iodide by adding potassium iodide to silver nitrate.

What extensive practical use is made of the change produced in silver salts by light?

IRON.

Experiment 100.

1. Dissolve a piece of iron wire in dilute hydrochloric acid.

What is given off?

What is the cause of the odor?

What remains undissolved?

What is in solution?

Write the equation representing the action of the acid on the iron.

2. To a few drops of the solution in water in a test-tube add at once a few drops of a dilute solution of sodium hydroxide.

What is the chemical change?

Compare with Experiment 97.

Write the equation.

3. Let the tube with its contents stand open, and shake it up from time to time.

What changes do you notice?

Explain what you have seen.

4. Heat another small portion of the solution of ferrous chloride to boiling; add a few drops of concentrated nitric acid, and boil again. Repeat this two or three times.

What change in color takes place?

What is now in solution?

5. Add a few drops of sodium hydroxide to the solution.

What is the chemical change?

Compare the precipitate with that in the tube which you have put aside (see 3).

How could you pass back from ferric to ferrous chloride?

CHROMIUM.

EXPERIMENT 101.

1. To a solution of 10 to 20 grams potassium dichromate slowly add a solution of potassium hydroxide until the color has turned pure yellow. Evaporate to crystallization.

What is the product?

Explain the change?

2. To the solution of the yellow salt just obtained add dilute nitric acid until the color has turned red. Evaporate to crystallization.

What is the product?

Explain the change?

EXPERIMENT 102.

Treat a little potassium chromate and a little potassium dichromate separately in test-tubes with hydrochloric acid.

Explain what takes place.

EXPERIMENT 103.

1. Add a little of a solution of potassium chromate or dichromate to a solution of barium chloride, and to a solution of lead acetate or nitrate.

Explain what takes place.

2. Do the same thing using potassium or sodium sulphate instead of potassium chromate.

How do the results compare with those obtained with the chromate?

Compare the composition of potassium chromate with that of potassium sulphate.

What resemblance is there?

LEAD.

EXPERIMENT 104.*

Dissolve 30–40 grams lead acetate (sugar of lead) in a liter of water, add a few drops of acetic acid, and put the solution in a wide-mouthed bottle. Suspend a piece of sheet-zinc in the middle of the solution, and let it stand for a day or two.

Describe what has taken place.

Compare with the action of zinc on copper sulphate.

Compare with the action of iron on sulphuric acid.

Give the equations expressing each of the reactions referred to.

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*It will be best for the teacher to perform this exper.ment and then set the vessel aside. Sometimes the lead-tree formed is very beautiful.

LEAD.

Experiment 105.

1. Cut a piece of sheet-lead an inch or two square and partly cover it with water in a shallow dish. Allow it to stand for several days, renewing the water from time to time. Then filter off and examine the solution to see whether there is any lead in solution.

(*a*) To a little of the solution in a test-tube add a few drops of hydrochloric acid.

Is a precipitate formed?

(*b*) To another small portion of the solution add a few drops of sulphuric acid.

Is a precipitate formed?

(*c*) Into a third portion pass a little hydrogen sulphide.

What takes place?

(*d*) Try the same experiments with a very dilute solution of lead acetate.

Of what practical importance is the above experiment?

2. Try the same experiment with a piece of iron.

Is there any iron in solution? [The easiest way to find this out is to add a few drops of a solution of potassium ferrocyanide * or yellow prussiate of potash, when, if iron is in solution, a blue color will be seen.]

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* See Experiment 8.

LEAD.

EXPERIMENT 106.

Treat a little minium with ordinary dilute nitric acid, and note the change in color.

Does lead pass into solution?

How do you know?

EXPERIMENT 107.

Treat a little lead peroxide with hydrochloric acid in a test-tube.

In what form is the lead after the experiment?

Is the product soluble or insoluble in water?

FERMENTATION.

EXPERIMENT 108.

Dissolve 20 to 30 grams commercial grape-sugar, or 20 to 30 c.cm. table syrup, in 1 to 2 liters of water in a flask. Connect the flask by means of a bent glass tube with a cylinder or bottle containing clear lime-water. The vessel containing the lime-water must be provided with a cork with two holes.

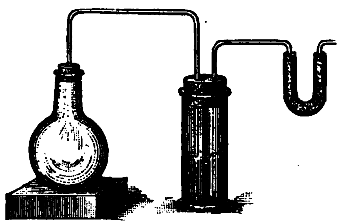

FIG. 24.

Through one of these passes the tube from the fermentation-flask ; through the other a tube connecting with a vessel containing solid caustic potash, the object of which is to prevent the air from acting upon the lime-water. The arrangement of the apparatus is shown in Fig. 24. Now add to the solution of grape-sugar or syrup some fresh brewer's yeast; close the connections and allow to stand.

What changes take place?

Explain all you have seen.

SOAP.

Experiment 109.

1. In a small iron pot boil for an hour or two a few ounces of lard with a solution of 20 grams caustic soda or sodium hydroxide in 250 c.cm. water. After cooling add a concentrated solution of common salt.

Explain what takes place.

What is the product?

2. Dissolve some of the product in water.

HARD WATER.

Experiment 110.

1. Make some hard water by passing carbon dioxide through dilute lime-water until the precipitate first formed is dissolved again. Filter.

2. Make a solution of soap by shaking up a few shavings of soap with water. Filter.

3. Add the solution of soap to the hard water.

Is a precipitate formed?

4. Rub a piece of soap between the hands wet with the hard water.

Explain what you observe.

Experiment 111.

Make some hard water by shaking a liter or two of water with a little powdered gypsum. Perform with it the same experiments as those first performed with the water containing calcium carbonate.

TANNIC ACID.

EXPERIMENT 112.

1. Boil 10 grams of powdered nutgalls with 60 c.cm. water, adding water from time to time. A solution of tannin is thus obtained. Filter after standing.

2. In a test-tube add to some of this solution a few drops of a solution of copperas (ferrous sulphate).

What is formed?

SUGGESTIONS FOR REVIEW.

By way of review it will be well to draw up a table containing the names and symbols of all the substances with which you have had to deal, classifying them into:

(1) *Elements* and *Compounds;*

(2) *Acids*, *Bases*, and *Salts.*

Under *Elements* state the principal source and the principal method for getting each.

Under *Compounds* state the source and the principal method for the preparation of each.

Classify all the compounds you have had to deal with into:

(1) Those which are gaseous;

(2) Those which are liquid;

(3) Those which are solid at the ordinary temperature;

(4) Those solids and liquids which easily undergo change when heated; (state what the change is, and give the equation expressing the change.)

Classify the compounds further into:

(1) Those which are soluble in water without change;

(2) Those which dissolve in water and are changed; (state what the change is, and give the equation expressing the change.)

(3) Those which are insoluble in water.

Determine which of the *chlorides* are insoluble or difficultly soluble in water.

This you can do by adding hydrochloric acid or a solution of some soluble chloride, as sodium chloride, to a solution of a soluble salt of the element you wish to experiment upon. Thus, for example, suppose you wish to know whether copper chloride is soluble or insoluble in water. You know that copper sulphate is soluble in water, as you have worked with its solution. If copper chloride is insoluble in water, then on adding hydrochloric acid or a solution of sodium chloride to the solution of copper sulphate a so-called *precipitate* of copper chloride will be formed.

Determine which of the *nitrates* are insoluble or difficultly soluble in water.

Determine which of the *sulphates* are insoluble or difficultly soluble in water.

Determine which of the *carbonates* are insoluble or difficultly soluble in water.

Determine with which *metals* hydrogen sulphide forms insoluble sulphides, by making solutions containing salts of the different metals, and passing hydrogen sulphide through them successively.

How are carbonates changed by hydrochloric acid? by nitric acid? by sulphuric acid?

How are chlorides changed by sulphuric acid?

How are nitrates changed by sulphuric acid?

How is hydrochloric acid affected by manganese dioxide?

How is nitric acid affected by copper? by lead? by tin?

How could you distinguish between hydrochloric, nitric, and sulphuric acids?

These questions can be multiplied indefinitely, and if care is taken that the answers are strictly accurate, they will be found to be highly profitable.

An excellent form of practice, alike interesting and stimulating, consists in efforts to determine by experiments which one of a given list of substances a certain specimen is.

The list below contains the names of the principal substances with which you have thus far had directly to deal in your work. You have handled them and have seen how they act toward different substances. Suppose now that a substance is given you and you know simply that it is one of those named in the list, how would you go to work to find out which one it is? You have a right to judge by anything in the appearance or in the conduct of the substance. If you reach a conclusion see whether you are right by further experiments. After your work is finished write out a clear account of what you have done, and state clearly your reasons for the conclusion which you have reached.

For example, suppose sodium chloride is given you. You see it is a white solid. On heating it in a small tube you see that it does not melt, but it breaks up into smaller pieces with a crackling sound. It is soluble in water. Hydrochloric acid causes no change when added to a little of the solid. Is it a carbonate? Sulphuric acid causes evolution of a gas. Has this an odor? How does it appear when allowed to escape into the air? Is it nitric acid? Collect some of it in water. How does this solution act on a solution of silver nitrate? By this time you have evidence that you are dealing with a chloride, but you do not yet know which chloride it is. It cannot be ammonium chloride. Why? It may be either potassium or sodium chloride. Try a small piece in the flame. What color? You now have good reasons for

believing that the substance you are dealing with is sodium chloride. To convince yourself, get a small piece of sodium chloride from the bottle known to contain it, and make a series of parallel experiments with this and see whether you get exactly the same results that you got with the specimen you were examining. If not, account for the differences.

By careful work there will be no serious difficulty in determining which one of the substances in the list you are dealing with.

LIST OF SUBSTANCES FOR EXAMINATION.

1. Sugar.
2. Mercuric oxide.
3. Calc spar.
4. Marble.
5. Copper.
6. Hydrochloric acid.
7. Nitric acid.
8. Sulphuric acid.
9. Zinc.
10. Tin.
11. Tartaric acid.
12. Sodium carbonate.
13. Ferrous sulphate (Copperas).
14. Roll sulphur.
15. Iron-filings.
16. Carbon disulphide.
17. Lead.
18. Potassium chlorate.
19. Manganese dioxide.
20. Charcoal.
21. Calcium sulphate (Gypsum).
22. Copper oxide.
23. Ammonium chloride.
24. Calcium oxide (Quicklime).
25. Sodium nitrate.
26. Ammonium nitrate.
27. Sodium chloride.
28. Potassium bromide.
29. Potassium iodide.
30. Iron sulphide.
31. Potassium carbonate.
32. Potassium nitrate.
33. Potassium dichromate.
34. Red lead (Minium).
35. Lead carbonate.

[The teacher will, of course, select the substance and give it to the pupil without any suggestion as to

what it is. After the pupil has shown that he can tell with certainty which substance he has, some simple mixtures of substances selected from the above list may next be given for examination. Thus charcoal and copper oxide; zinc and tin; mercuric oxide and iron filings; etc., etc. Such work as that just described is more profitable at this stage than what is commonly called chemical analysis, which is performed according to a few rules. Upon these rules reliance is soon placed and rule-of-thumb work follows. Chemical analysis with a broad foundation of facts acquired is of the greatest benefit. Without this basis it does more harm than good.]

WEIGHTS AND MEASURES.

Troy or Apothecaries' Weight.

Pound.		Ounces.		Drams.		Scruples.		Grains.		Grams.
1	=	12	=	96	=	288	=	5760	=	372.96
		1	=	8	=	24	=	480	=	31.08
				1	=	3	=	60	=	3.885
						1	=	20	=	1.295
								1	=	0.0647

Avoirdupois Weight.

Pound.		Ounces.		Drams.		Grains.		Grams.
1	=	16	=	256	=	7000	=	453.25
		1	=	16	=	437.5	=	28.328
				1	=	27.343	=	1.77

Imperial Measure.

Gallon.		Pints.		Fluid Ounces.		Fluid Drams.		Minims.
1	=	8	=	160	=	1280	=	76800
		1	=	20	=	160	=	9600
				1	=	8	=	480
						1	=	60

METRIC SYSTEM.

Measures of Length.

		English Inches.
1 Millimeter	=	.03937
1 Centimeter	=	.39371
1 Decimeter	=	3.93710
1 Meter	=	39.37100

Measures of Capacity.

		English Imperial Measure.			
		Pint.	F. Oz.	F. Dram.	Min.
1 Cubic Centimeter	=	0	0	0	16.3
1 Centiliter (10 c.cm.)	=	0	0	2	43
1 Deciliter (100 c.cm.)	=	0	3	3	2
1 Liter	=	1	15	1	43

Measures of Weight.

		English Grains.		Avoirdupois.		
				Pound.	Oz.	Dms.
1 Gram	=	15.4323				
1 Kilogram	=	15432.348	=	2	3	5